Summer Workday Daily Mobile NOx and State Ranking

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MARAMA MOVES Workgroup conference call
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Summer Daily NOx (tons/day)

- Mobile a significant source sector
- Annual numbers (TPY) too coarse of a resolution
- Implication for summer ozone
- Parameter used in transportation conformity and mobile budgets

Approach

Summer Workday Daily NOx

- EPA 2011/2018 modeling files contain emissions by county & calendar date (month, day of month, and Julian day)
- Calendar dates were translated to corresponding day of the week (ex, Monday, Tuesday, etc.)

  January 12, 2011 ⇨ Wednesday

  July 16, 2011 ⇨ Saturday

- Summarize workday emissions (Monday to Friday, excluding weekend) over a selected episode period
- Average total workday emissions by the number of workdays in the episode

NOx in tons/day

Summer Episodes Selected

Period	Duration	# of days averaged	Notes
Ozone season	May, Jun, Jul, Aug, Sep	110 days	summer ozone, HEDD, mobile budgets
Summer months	Jul, Aug, Sep	66 days	peak summer/ozone season
June episode (NE)	June 6, 7, 8, 9	4 days	2011 bad air quality in NE
July episode (NE)	July 20, 21	2 days	2011 bad air quality in NE

Only weekday NOx were included in calculations (weekends were excluded).
Daily NOx (tons/day) is an average over the number of days in the episode (i.e., 3rd column).
Data were obtained from 2011-2018 NEI v1 platform posted by EPA.

Possible minor flaws:

1. **NEI data was generated in GMT time scale. "True" workday emissions should be in local time (such as EST, PST). The approach will be a few hours (5 hours for EST) off due to time differences between GMT and local time.**
2. **Holidays (ex., July 4) were not excluded.**

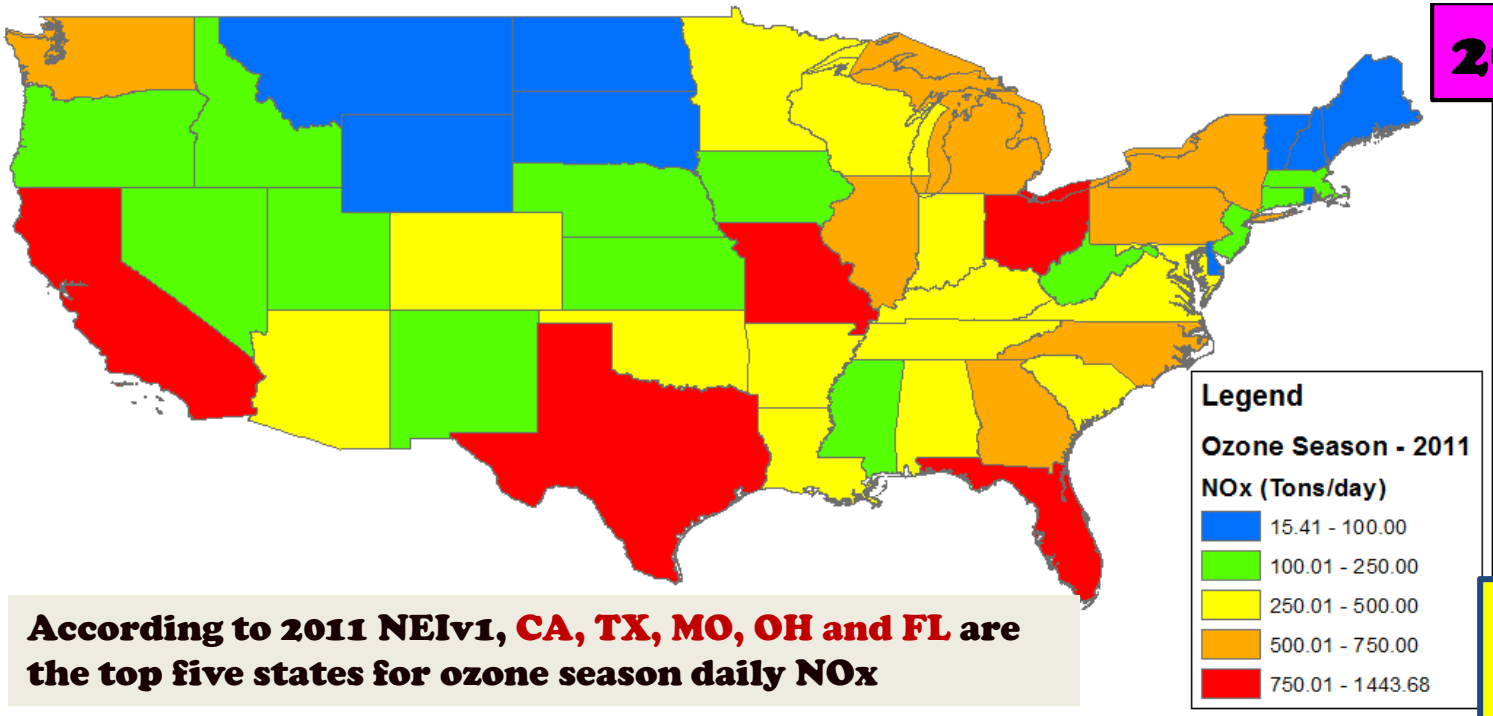
SMOKE-MOVES v3.1 cannot handle local time (such as EST) ← EPA please fix

Summer Daily NOx by State

Aggregated over state counties

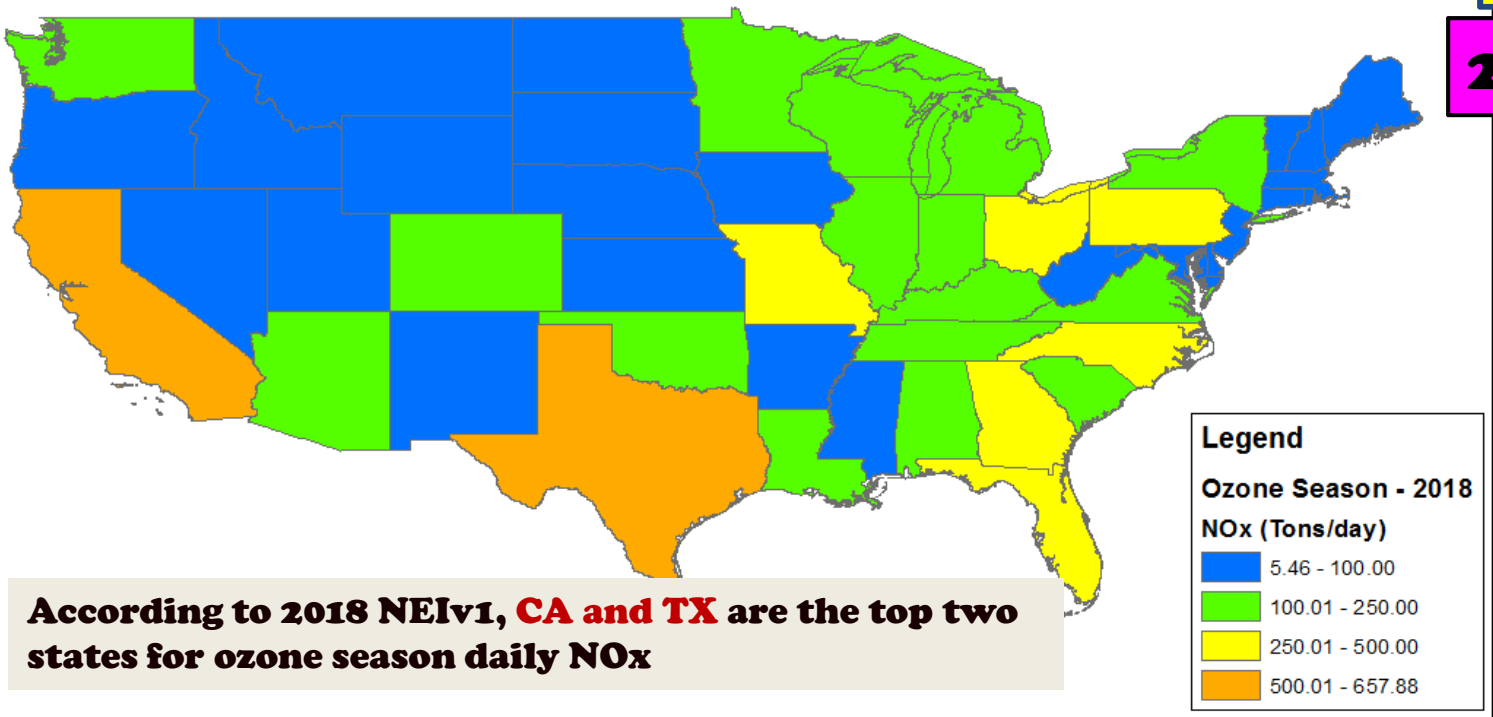
Ozone season Daily NOx

2011



According to 2011 NEIv1, CA, TX, MO, OH and FL are the top five states for ozone season daily NOx

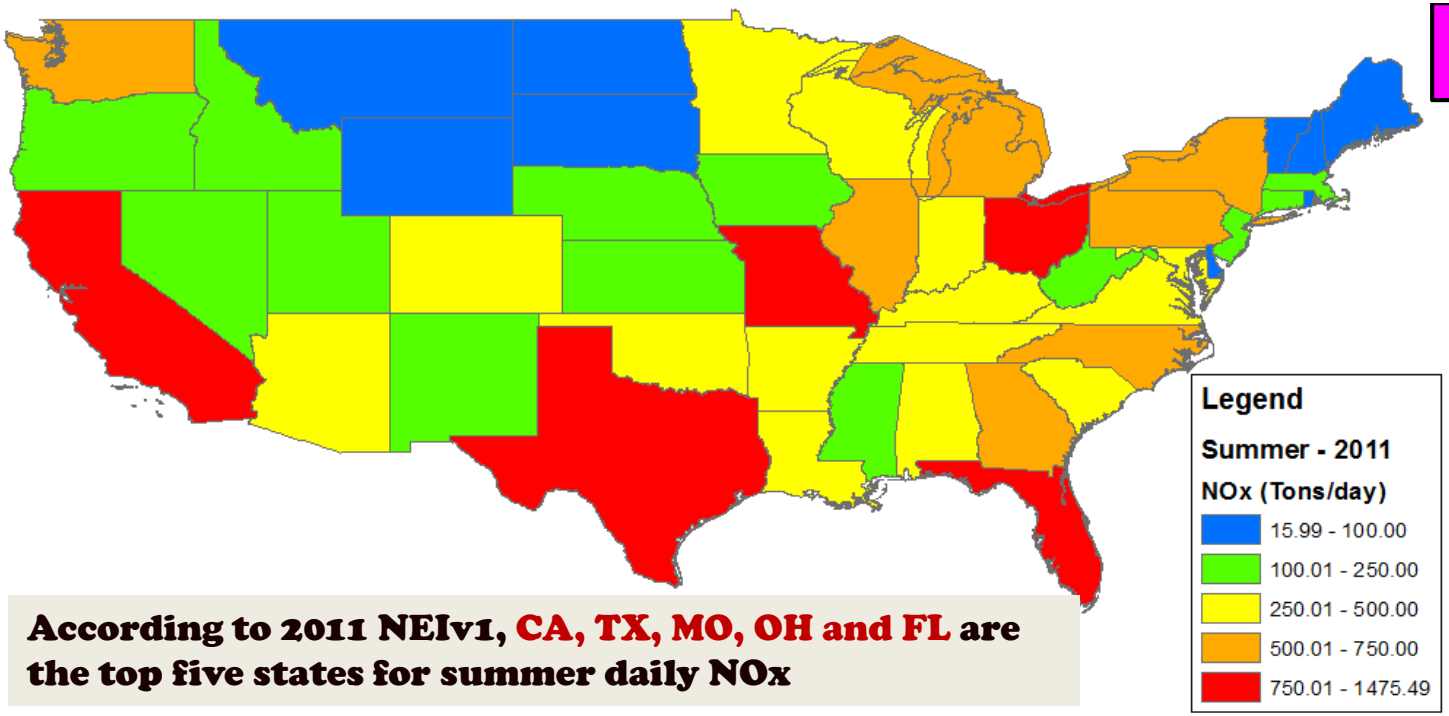
2018



According to 2018 NEIv1, CA and TX are the top two states for ozone season daily NOx

Summer Daily NOx

2011



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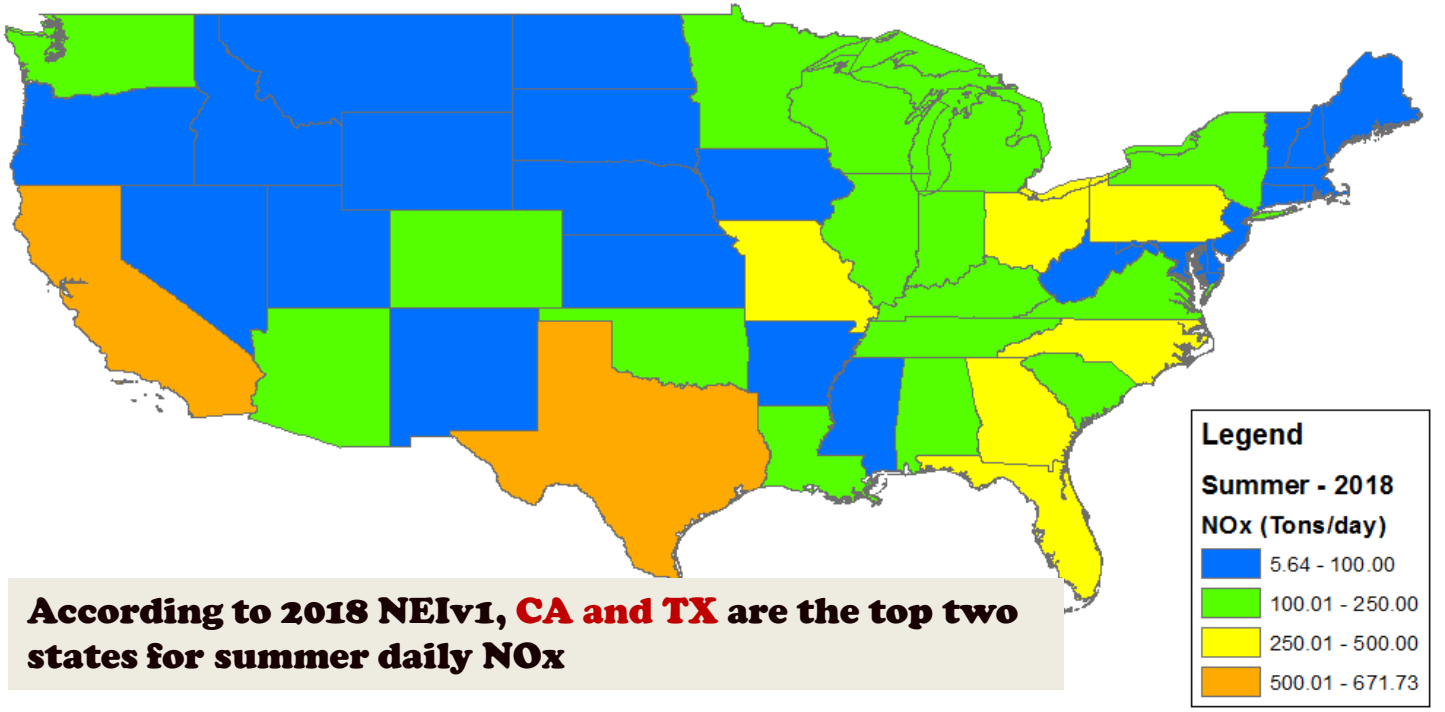
2018



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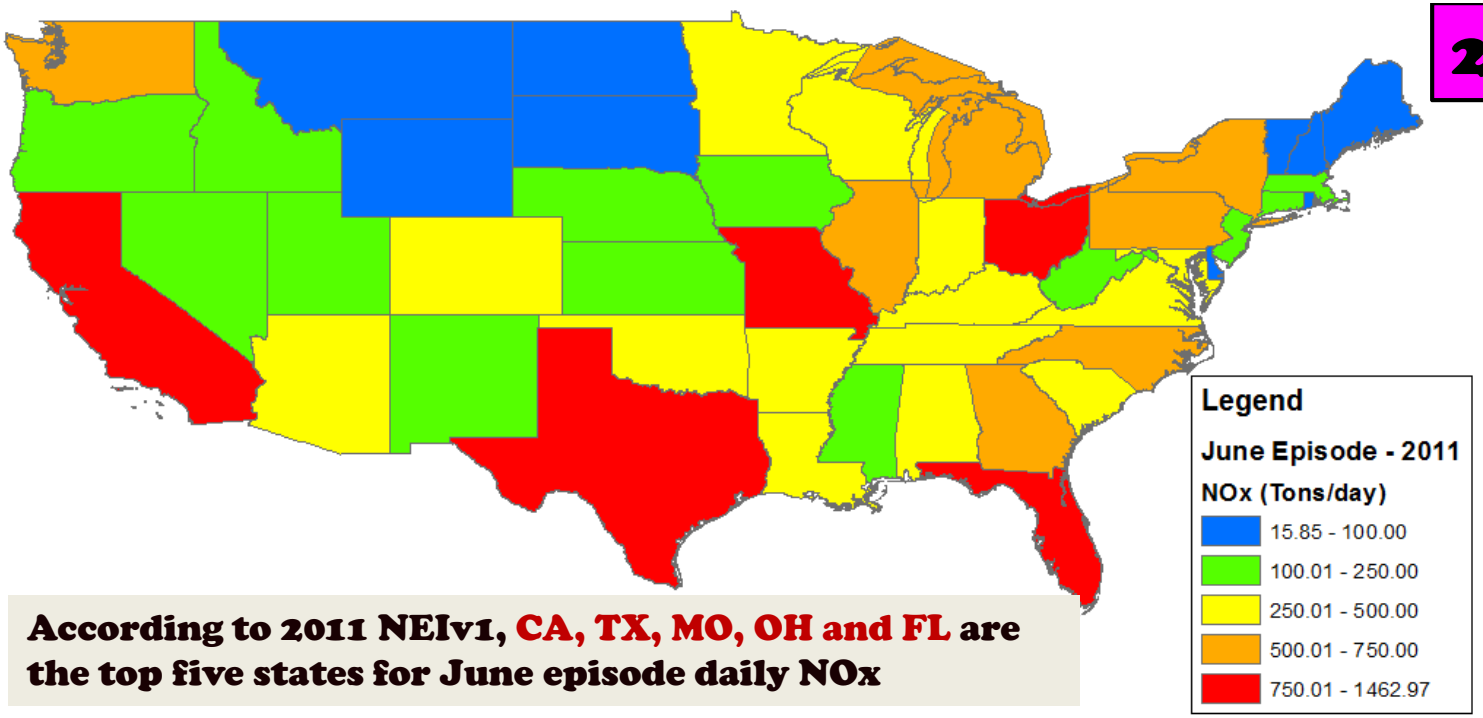
June Episode Daily NOx

2011



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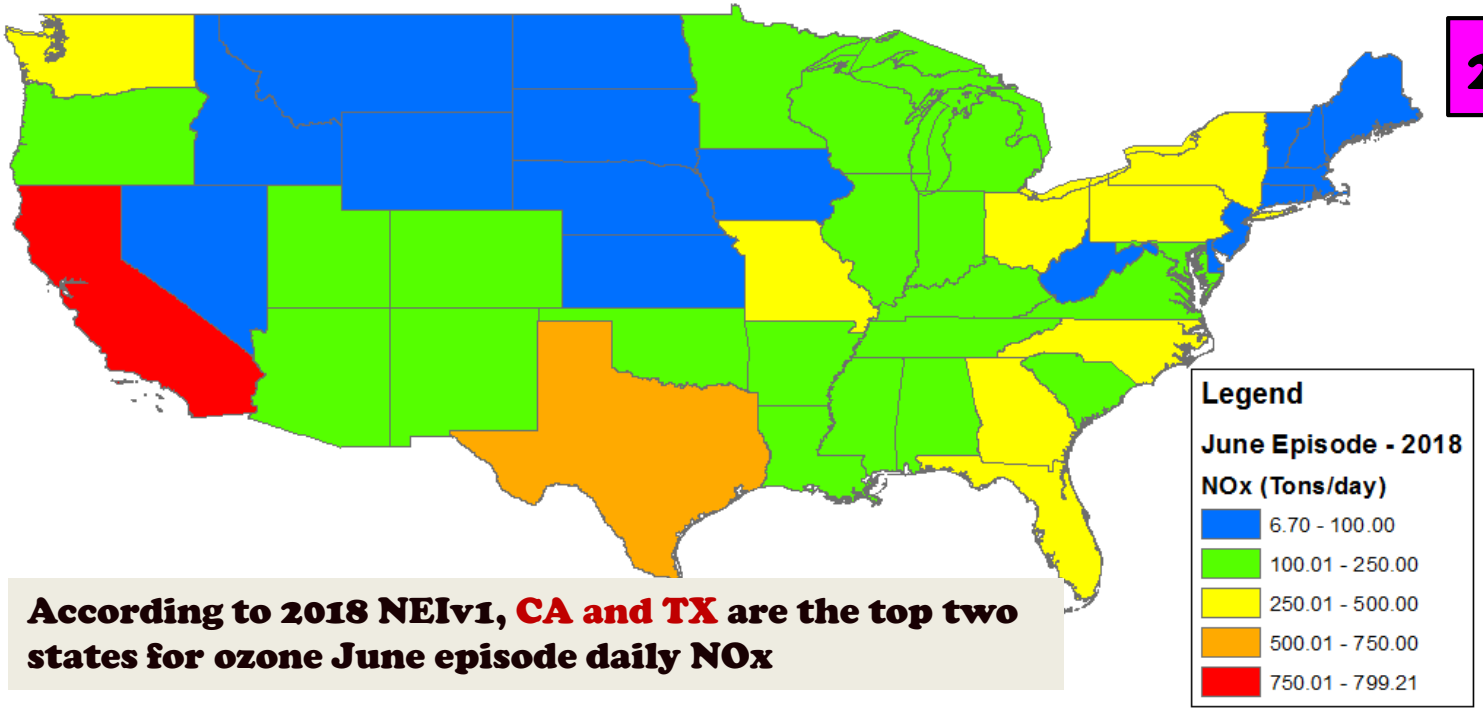
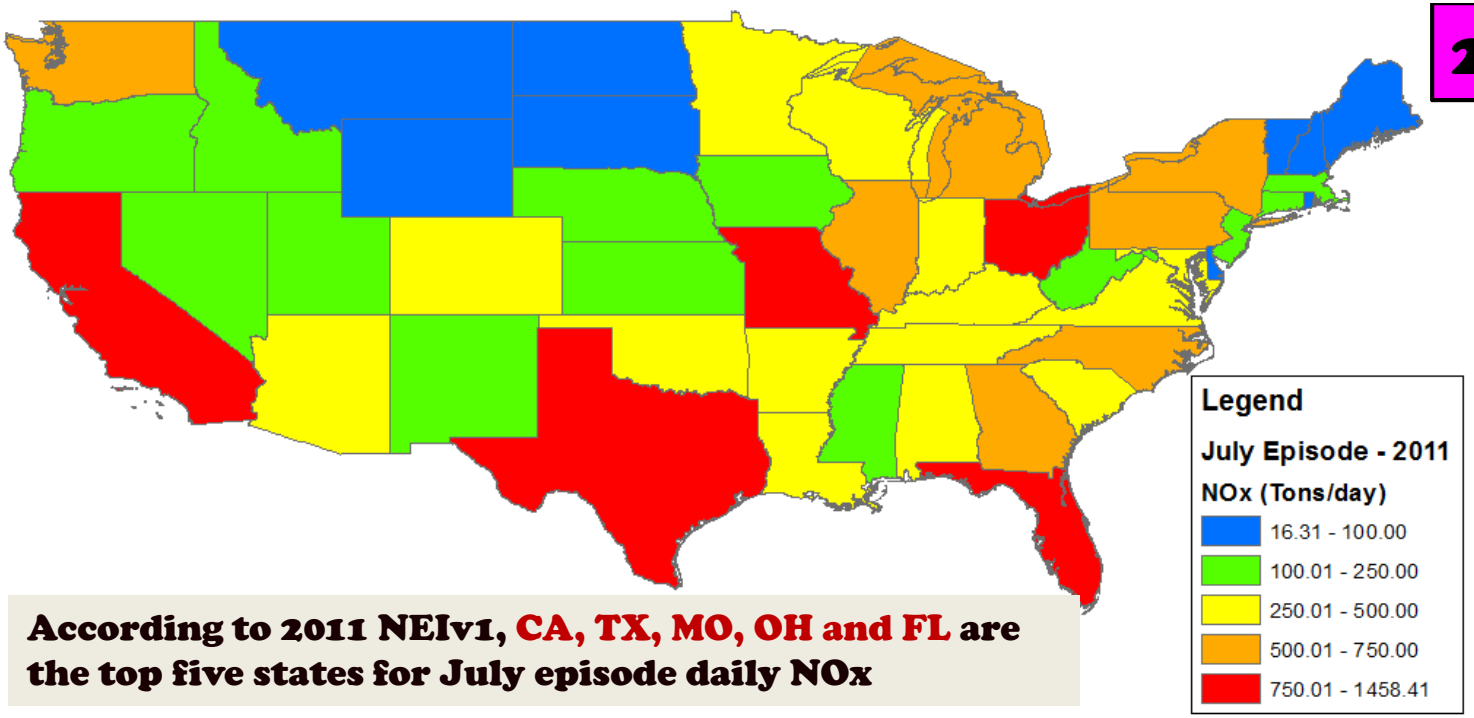
2018



According to 2018 NEIv1, CA and TX are the top two states for ozone June episode daily NOx

July episode Daily NOx

2011



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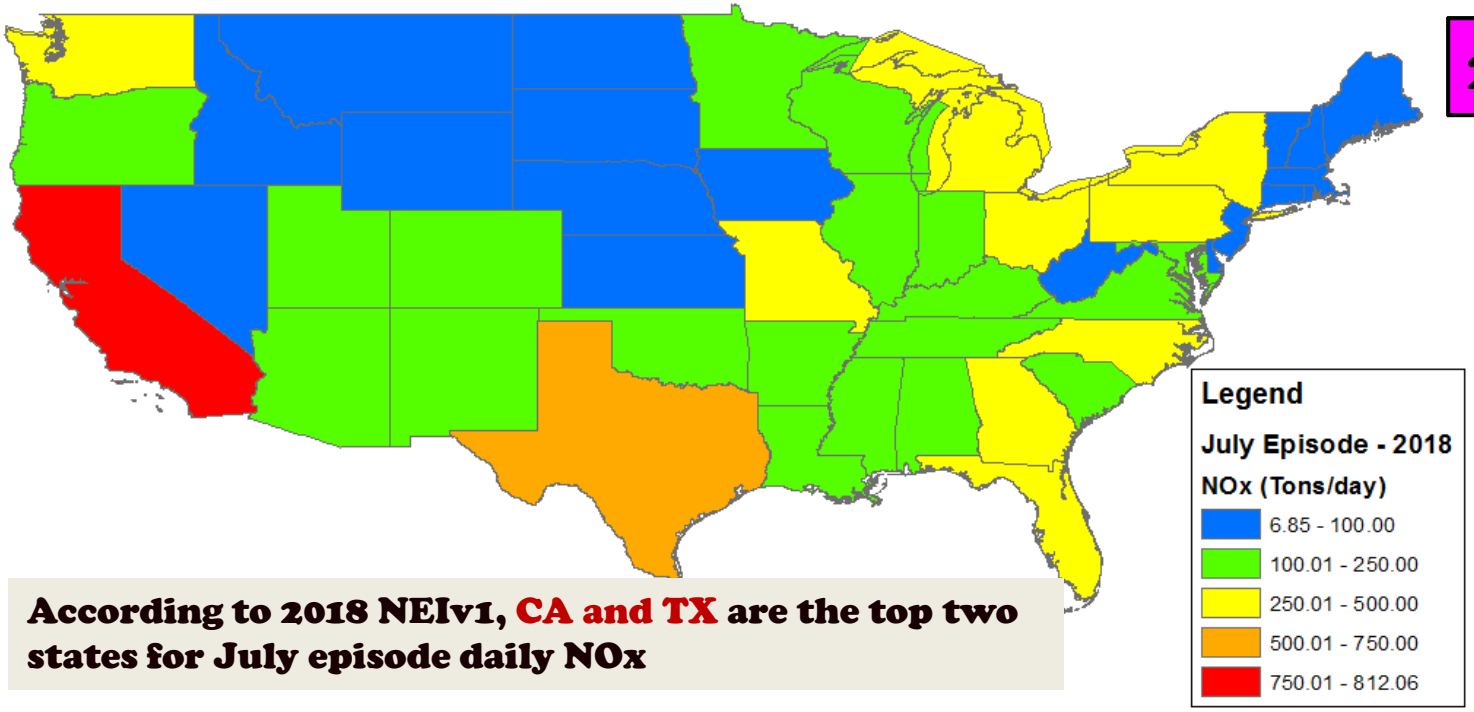
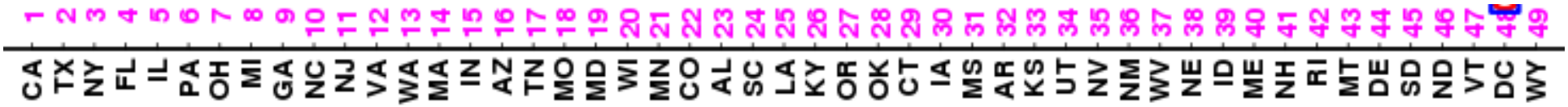
2018



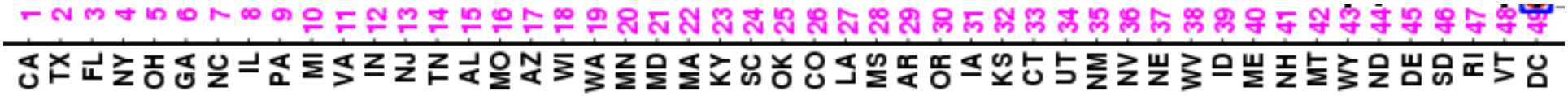
According to 2018 NEIv1, CA and TX are the top two states for July episode daily NOx

State Ranking

(1) ranked by 2010 census (May 27 presentation)



(2) ranked by 2011 VMT (April 28 presentation)



Same rank: CA (1), TX (2), SC (24), UT (34), ID (39), ME (40), NH (41)

Wild swing in two rankings: AL, WA, MA, WY

Census data is in line with VPOP for passenger cars (May 27 presentation)
Census data can be considered a surrogate for VPOP for passenger cars

2011 Summer Daily NOx – cold hard numbers

Rank	Ranked by 2010 census	Ranked by 2011 VMT
1	CA	CA
2	TX	TX
3	NY	FL
4	FL	NY
5	IL	OH
6	PA	GA
7	OH	NC
8	MI	IL
9	GA	PA
10	NC	MI
11	NJ	VA
12	VA	IN
13	WA	NJ
14	MA	TN
15	IN	AL
16	AZ	MO
17	TN	AZ
18	MO	WI
19	MD	WA
20	WI	MN
21	MN	MD
22	CO	MA
23	AL	KY
24	SC	SC
25	LA	OK
26	KY	CO
27	OR	LA
28	OK	MS
29	CT	AR
30	IA	OR
31	MS	IA
32	AR	KS
33	KS	CT
34	UT	UT
35	NV	NM
36	NM	NV
37	WV	NE
38	NE	WV
39	ID	ID
40	ME	ME
41	NH	NH
42	RI	MT
43	MT	WY
44	DE	ND
45	SD	DE
46	ND	SD
47	VT	RI
48	DC	VT
49	WY	DC

Rank	(1) 2011 ozone daily NOx		(2) 2011 summer daily NOx		(3) 2011 June episode daily NOx		(4) 2011 July episode daily NOx	
1	TX	1443.7	TX	1475.5	TX	1463.0	TX	1458.4
2	CA	1349.1	CA	1379.6	CA	1346.6	CA	1379.4
3	FL	1001.0	FL	1029.6	FL	1014.4	FL	1012.8
4	OH	874.7	OH	890.1	OH	888.0	OH	904.4
5	MO	782.3	MO	768.4	MO	766.0	MO	766.9
6	GA	696.2	GA	705.4	GA	715.3	GA	669.1
7	NC	628.4	NC	647.9	NC	630.5	PA	634.2
8	PA	624.0	PA	629.8	PA	624.2	NC	632.9
9	NY	596.6	NY	606.2	NY	596.9	NY	616.2
10	MI	581.0	MI	586.8	MI	569.7	MI	591.5
11	IL	531.3	IL	537.0	IL	536.1	IL	543.7
12	WA	509.0	WA	516.6	WA	508.3	WA	508.1
13	TN	456.3	TN	466.6	TN	463.6	TN	463.4
14	IN	451.9	IN	458.5	IN	451.1	IN	462.8
15	VA	436.8	VA	440.5	VA	442.4	VA	433.5
16	AL	425.0	AL	436.2	AL	435.9	AL	423.9
17	AZ	371.0	AZ	376.7	AZ	374.1	AZ	370.6
18	MN	345.5	MN	348.3	MN	351.3	WI	345.7
19	WI	344.9	WI	347.8	WI	345.0	MN	341.8
20	KY	328.3	KY	331.1	KY	325.9	OK	329.4
21	SC	318.7	OK	328.1	SC	321.6	KY	328.5
22	OK	316.6	SC	327.2	OK	315.2	SC	322.9
23	LA	304.0	LA	312.0	LA	308.4	LA	302.8
24	CO	280.2	CO	287.8	CO	278.9	CO	290.0
25	AR	253.7	AR	257.4	MD	257.8	MD	257.7
26	MD	253.5	MD	257.1	AR	253.9	AR	255.8
27	MS	232.8	MS	238.6	MS	236.6	UT	235.9
28	OR	226.9	UT	233.8	OR	224.6	MS	231.5
29	UT	226.5	OR	230.8	UT	222.4	OR	225.9
30	NM	215.1	NM	220.3	NM	216.3	NM	220.3
31	NJ	208.4	NJ	211.0	NJ	207.4	NJ	211.1
32	IA	191.1	MA	195.7	MA	194.4	KS	198.4
33	MA	190.7	KS	194.0	IA	188.0	MA	198.1
34	KS	189.0	IA	191.6	KS	187.8	NV	189.2
35	NV	183.7	NV	188.9	NV	181.2	IA	189.0
36	ID	161.3	ID	167.5	ID	152.8	ID	172.3
37	NE	124.9	NE	127.0	NE	124.1	NE	129.8
38	CT	112.8	CT	115.0	CT	112.7	CT	116.9
39	WV	110.3	WV	112.0	WV	109.9	WV	110.7
40	WY	83.9	WY	85.8	WY	83.8	WY	86.2
41	ME	83.1	ME	84.8	ME	82.1	ME	84.9
42	MT	81.1	MT	82.7	MT	80.2	MT	81.9
43	ND	62.1	ND	62.7	ND	61.9	ND	62.2
44	SD	58.0	SD	58.6	SD	57.2	SD	58.9
45	NH	52.7	NH	53.6	NH	52.8	NH	54.0
46	DE	43.2	DE	44.2	DE	44.3	DE	44.0
47	VT	31.0	VT	31.5	VT	30.8	VT	31.3
48	RI	26.2	RI	26.6	RI	26.2	RI	26.8
49	DC	15.4	DC	16.0	DC	15.8	DC	16.3

2018 Summer Daily NOx – cold hard numbers

Ranked by 2010 census

CA	TX	NY	FL	IL	PA	OH	MI	GA	NC	NJ	VA	WA	MA	IN	AZ	TN	MO	MD	WI	MN	CO	AL	SC	LA	KY	OR	OK	CT	IA	MS	AR	KS	UT	NV	NM	WV	NE	ID	ME	NH	RI	MT	DE	SD	ND	VT	DC	WY
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49

Ranked by 2011 VMT

CA	TX	FL	NY	OH	GA	NC	IL	PA	MI	VA	IN	NJ	TN	AL	MO	AZ	WI	WA	MN	MD	MA	KY	SC	OK	CO	LA	MS	AR	OR	IA	KS	CT	UT	NM	NV	NE	WV	ID	ME	NH	MT	WY	ND	DE	SD	RI	VT	DC
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49

(5) 2018 ozone daily NOx

CA	TX	FL	OH	MO	GA	NC	PA	NY	WA	MI	IL	IN	VA	TN	AL	AZ	MN	WI	KY	SC	OK	LA	CO	AR	MD	OR	UT	MS	NM	NJ	IA	KS	NV	ID	MA	NE	WV	CT	WY	MT	ME	ND	SD	NH	DE	VT	RI	DC
657.9	550.9	364.7	346.6	311.3	276.4	266.8	253.0	234.1	230.0	215.6	180.9	170.3	169.1	168.9	160.2	139.2	135.3	130.9	126.2	119.0	118.9	115.6	107.0	96.9	96.4	89.3	88.1	87.7	83.5	75.3	73.9	71.4	70.8	69.6	67.6	47.4	42.7	36.9	32.2	31.9	26.1	23.8	22.5	21.5	15.9	12.0	10.1	5.5

(6) 2018 summer daily NOx

CA	TX	FL	OH	MO	GA	NC	PA	NY	WA	MI	IL	TN	IN	VA	AL	AZ	MN	WI	KY	OK	SC	LA	CO	AR	MD	UT	OR	MS	NM	NJ	IA	KS	NV	ID	MA	NE	WV	CT	WY	MT	ME	ND	SD	NH	DE	VT	RI	DC
671.7	563.3	374.6	352.0	304.5	279.6	274.8	254.8	236.5	233.5	217.4	182.0	172.1	171.9	170.0	163.7	141.3	136.0	131.4	126.8	122.7	121.8	118.2	109.1	98.0	97.3	90.6	90.5	89.6	85.2	75.7	73.7	72.9	72.5	72.3	68.8	48.0	43.2	37.5	32.8	32.3	26.5	23.9	22.6	21.8	16.2	12.1	10.2	5.6

(7) 2018 June episode daily NOx

CA	TX	FL	OH	MO	GA	NC	PA	NY	WA	MI	IL	TN	VA	IN	AL	AZ	MN	WI	KY	SC	OK	LA	CO	MD	AR	OR	MS	UT	NM	NV	NJ	IA	KS	NV	MA	ID	NE	WV	CT	WY	MT	ME	ND	SD	NH	DE	VT	RI	DC
799.2	665.1	435.5	419.5	383.2	330.0	302.6	297.8	284.0	272.7	246.7	222.7	204.1	202.7	202.0	194.9	167.3	161.4	155.5	149.0	143.7	139.9	139.7	125.8	117.6	116.4	106.7	105.1	103.2	101.4	86.2	86.2	84.4	83.1	81.6	77.7	55.0	50.1	43.7	38.6	37.1	31.0	27.9	25.7	25.6	19.0	13.8	11.9	6.7

(8) 2018 July episode daily NOx

CA	TX	FL	OH	MO	GA	NC	PA	NY	WA	MI	IL	IN	TN	VA	AL	AZ	MN	WI	KY	OK	SC	LA	CO	AR	MD	UT	OR	MS	NM	NV	KS	ID	NJ	IA	MA	NE	WV	CT	WY	MT	ME	ND	SD	NH	DE	VT	RI	DC
812.1	663.1	434.8	424.4	381.2	309.4	303.7	300.8	288.4	272.0	253.6	223.3	205.3	203.9	198.5	190.4	165.3	155.0	153.4	149.6	145.3	144.3	137.4	129.2	116.9	116.6	107.9	106.7	103.1	102.7	88.7	86.9	86.6	86.4	83.9	81.4	56.7	50.2	44.1	39.1	37.1	31.6	27.5	25.9	25.8	18.9	13.8	11.9	6.8

General Summary on Daily NOx by State

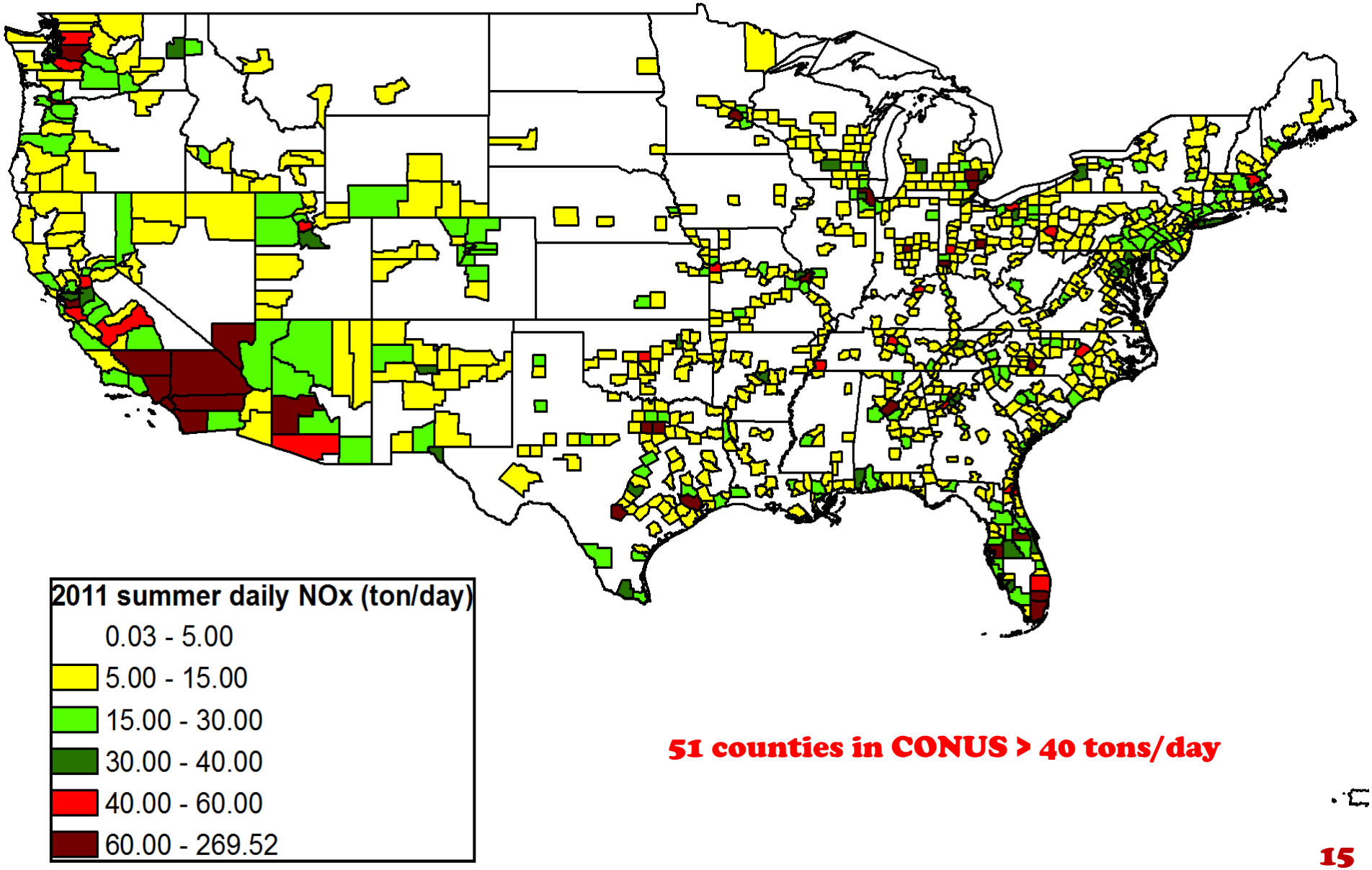
- Daily NOx are very similar, both in magnitude and in ranking, among all four summer episodes
- Ranking from 2011 to 2018 changes only slightly
- Meteorology does not make much difference to emissions or ranking
- CA, TX, MO, OH and FL are the top five states for daily NOx from mobile sources
- CA is projected in 2018 to replace TX as the top spot in daily NOx. What is the reason for this switch?

Summer Daily NOx by County

- Resolution at state level is too coarse
- MOVES modeling is conducted by county

2011 Summer Daily NOx by County

(July to September)



51 counties in CONUS > 40 tons/day

Highest Daily NOx by County

(> 40 tons/day)

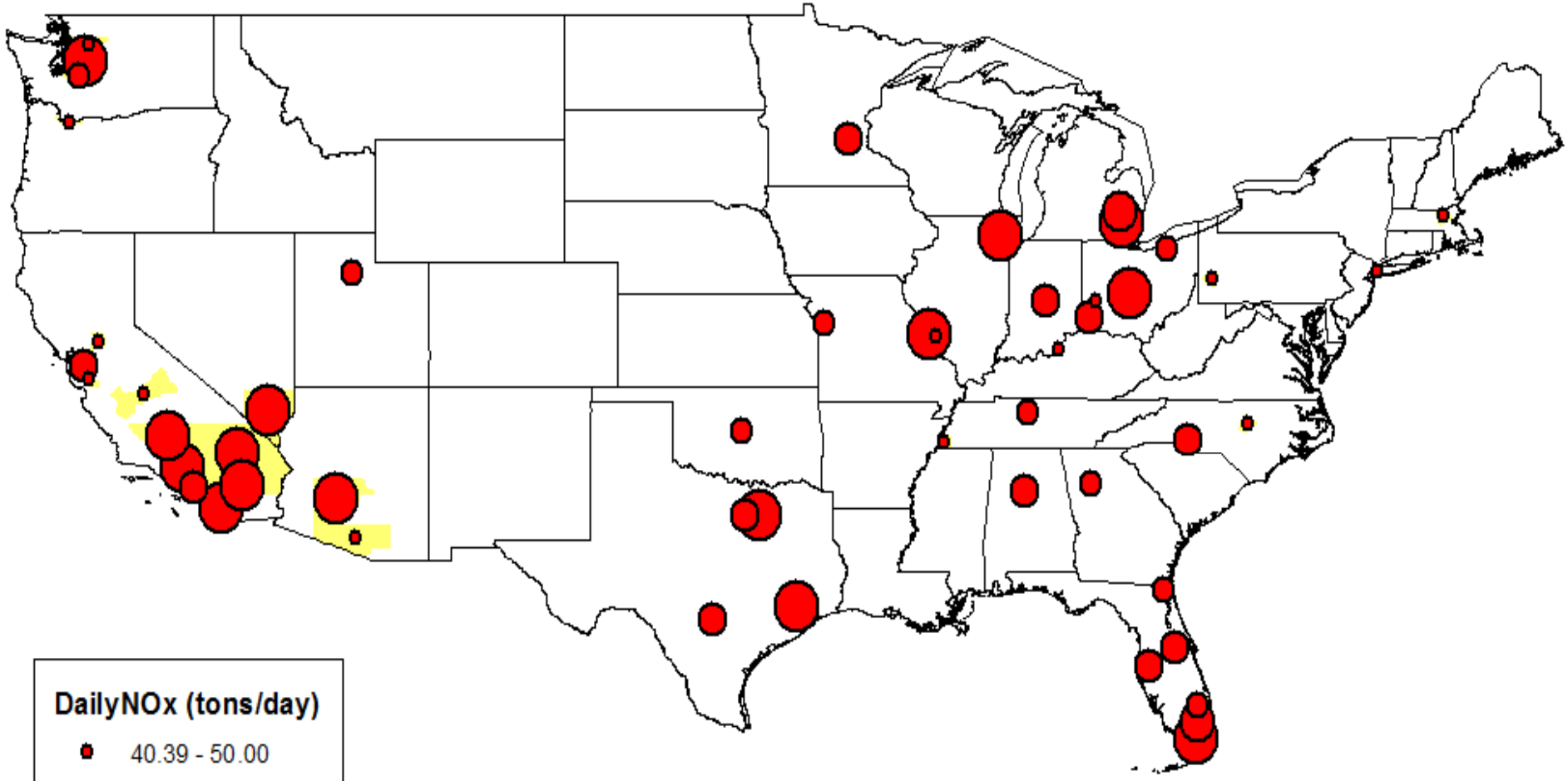
NE

AL	01073-Jefferson			1
AZ	04013-Maricopa	04019-Pima		2
CA	06001-Alameda	06019-Fresno	06029-Kern	
	06037-LosAngeles	06059-Orange	06065-Riverside	
	06067-Sacramento	06071-SanBernardino	06073-SanDiego	
	06085-SantaClara			10
FL	12011-Broward	12031-Duval	12057-Hillsborough	
	12086-Miami-Dade	12095-Orange	12099-PalmBeach	6
GA	13121-Fulton			1
IL	17031-Cook			1
IN	18097-Marion			1
KY	21111-Jefferson			1
MA	25017-Middlesex			1
MI	26125-Oakland	26163-Wayne		2
MN	27053-Hennepin			1
MO	29095-Jackson	29189-St.Louis	29510-St.Louiscity	3
NV	32003-Clark			1
NY	36081-Queens			1
NC	37119-Mecklenburg	37183-Wake		2
OH	39035-Cuyahoga	39049-Franklin	39061-Hamilton	
	39113-Montgomery			4
OK	40109-Oklahoma			1
OR	41051-Multnomah			1
PA	42003-Allegheny			1
TN	47037-Davidson	47157-Shelby		2
TX	48029-Bexar	48113-Dallas	48201-Harris	
	48439-Tarrant			4
UT	49035-SaltLake			1
WA	53033-King	53053-Pierce	53061-Snohomish	3

Number of counties greater than 40 tons/day

Highest Daily NOx by County

(> 40 tons/day)

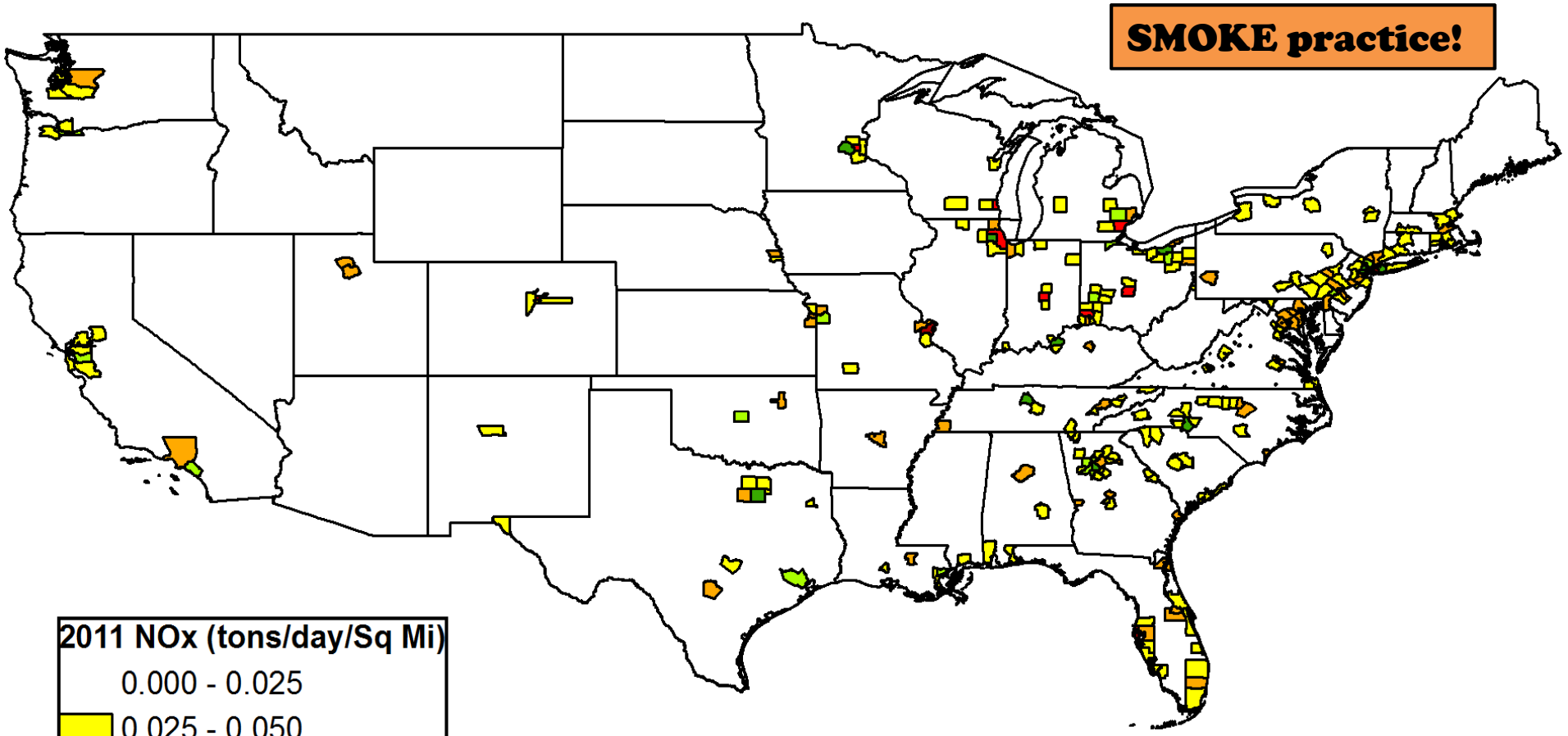


County-wise, highest daily NOx corresponds to major cities

NOx per County Square Miles

- Resolution at county level is still too coarse.
- "Normalized" emissions by land size
- County land size (or area) in square miles were obtained from 2010 census data

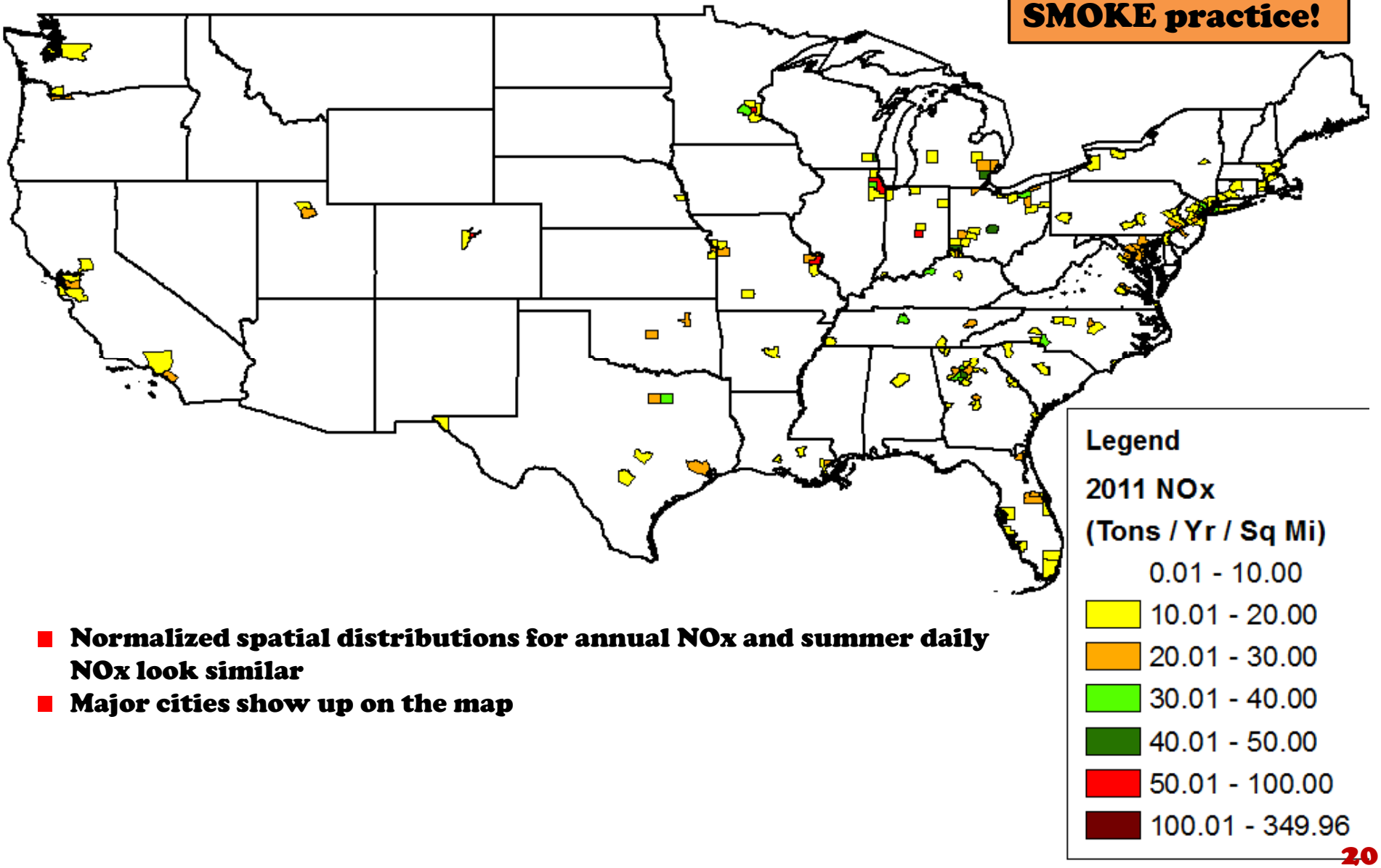
2011 Summer Daily NOx per County Square Miles



- Summer (July-Sep) daily NOx is normalized by county square miles
- Normalization is similar to SMOKE in which county emissions are allocated to grid cells for that county
- Major cities (hot spots) show up on the map
- The method is useful for emission QA.

2011 Annual NOx per County Square Miles

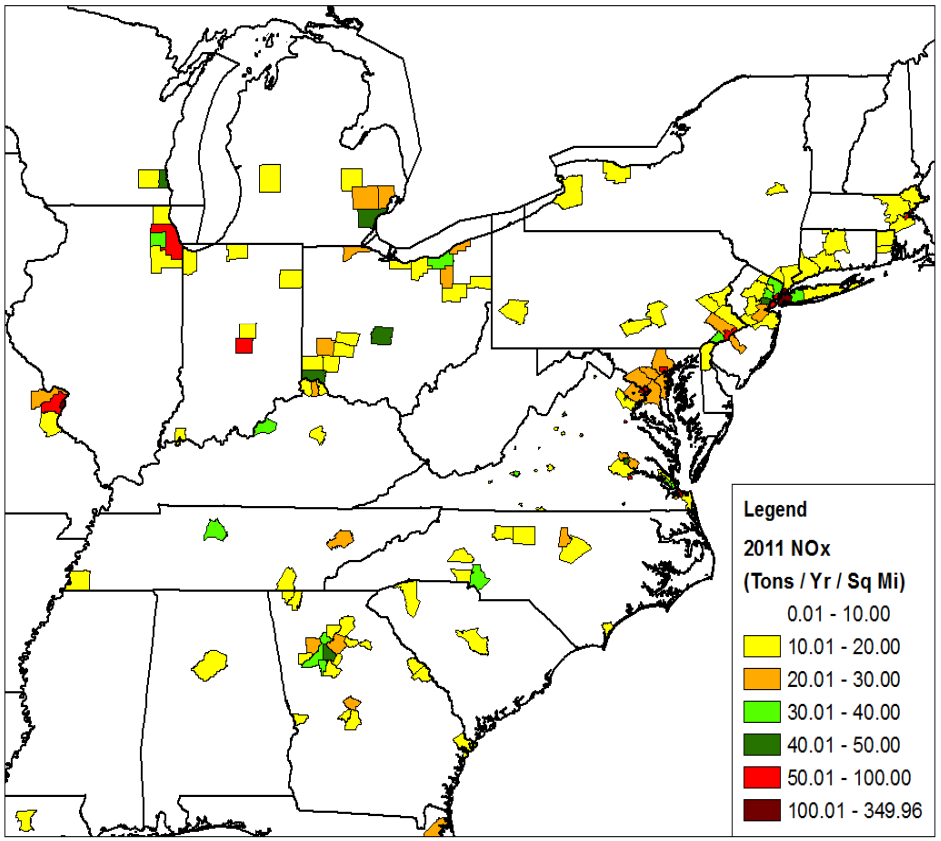
SMOKE practice!



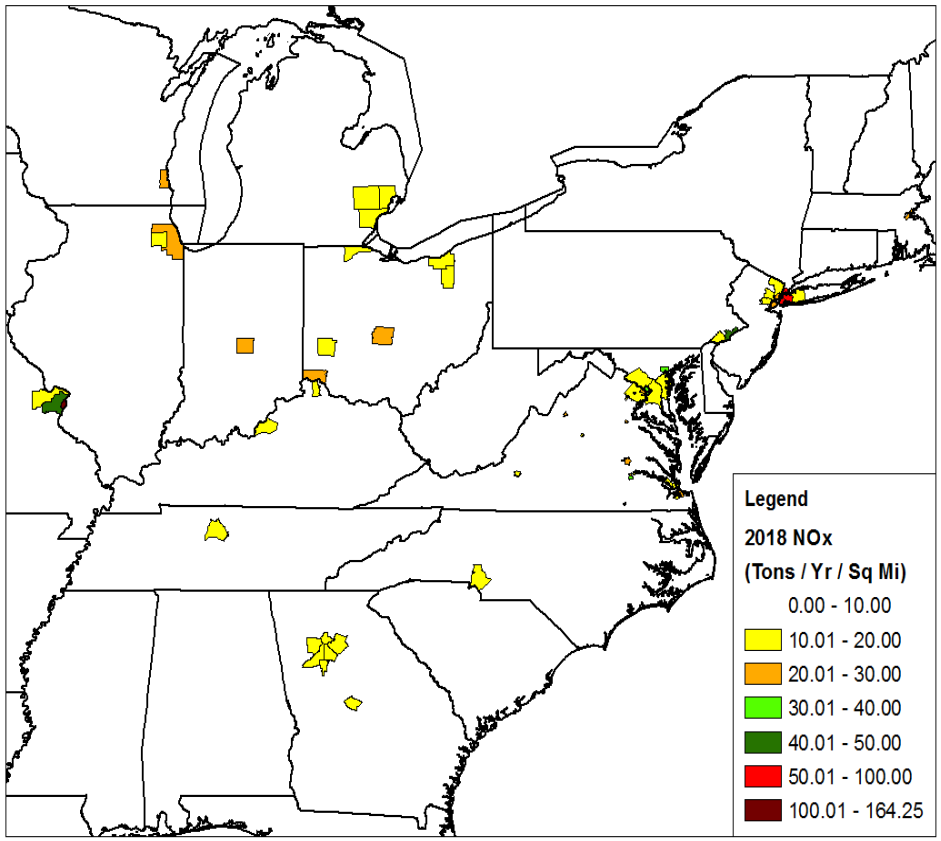
- **Normalized spatial distributions for annual NOx and summer daily NOx look similar**
- **Major cities show up on the map**

Annual NOx per County Square Miles

2011



2018



2011 NOx County Hot Spots by County Square Miles

Top 15 hot spots

FIPS	Annual (tons/year/sq mile)	Daily (tons/day/sq mile)	CName
36061	349.9626	1.122862	New York County—New York
29510	237.2394	0.738439	St. Louis City—Missouri
36005	174.0538	0.556779	Bronx County—New York
36047	172.3985	0.551859	Kings County—New York
36081	117.0593	0.372167	Queens County—New York
06075	98.63251	0.327523	San Francisco County—California
29189	88.23918	0.274931	St. Louis County—Missouri
11001	81.38605	0.261847	District of Columbia—District of Columbia
42101	83.43138	0.259958	Philadelphia County—Pennsylvania
51630	67.90241	0.200973	Fredericksburg City—Virginia
24510	65.29381	0.198133	Baltimore City—Maryland
08031	58.82967	0.193828	Denver County—Colorado
25025	59.92275	0.176978	Suffolk County—Massachusetts
27123	59.10064	0.174807	Ramsey County—Minnesota
51520	52.69731	0.169730	Bristol City—Virginia

- Ranking is based on summer daily NOx, but ranks by annual are similar
- NY data in 2011NEI v1 was from MOVES defaults (not state-supplied)
- Unlike county and state ranking, most hot spots are now in northeast states.

Overall Ranking Summary

- By state
- By county
- By county land size

Ranking Summary
-- According to EPA 2011 NEI v1 --

- **Top 10 states in the nation:**

  CA, TX, FL, OH, MO, GA, NC, PA, NY, WA

- **Northeast MARAMA states:**

  PA, NY, VA, MD, NJ, MA, CT, ME, NH, DE, VT, RI, DC

- **Southeast SESARM states:**

  FL, GA, NC, TN, VA, AL, KY, SC, MS, WV

- **Top 10 NOx by county (the highest NOx in tons/day):**

  Los Angles-CA (270), Maricopa-AZ (167), Cook-IL (159), Harris-TX (156), St. Louis-MO (140), King-WA (122), Clark-NV (106), San Bernardino-CA (105), Dallas-TX (99), Miami-Dade-FL (93)

- **Top 15 hot spots by county square miles (from SMOKE perspective):**

  NY (4), MO (2), CA (1), DC, PA (1), VA (2), MD (1), CO (1), MA (1), MN (1)

- **Daily NOx (by county) for southeast states are higher than northeast states (stringent control programs such as CALEV in place? Or older vehicles in the SE? – many possibilities)**

Conclusions

- A methodology of calculating ozone season and summer workday daily emissions suitable for transportation conformity and mobile budget is presented
- Daily NOx from mobile sources shows consistent spatial patterns -- by state, by county, or by county land size -- concentrating on major metropolitan areas
- The study is limited by data quality of 2011/2018 NEI version1 (MOVES defaults instead of state-supplied)
- Method using emissions per county square miles can be useful for emissions QA

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